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Test Report

Prepared for: Ubiquiti Networks, Inc

Model: NBE-M5-16

Description: NanoBeam M5 16

Serial Number: N/A

FCC ID: SWX-NBE5M16

To

FCC Part 15.407

Date of Issue: July 31, 2015

On the behalf of the applicant:	**Ubiquiti Networks, Inc** **91 E. Tasman Drive** **San Jose, CA 95134**
Attention of:	**Michael Taylor, Compliance Manager** **Ph: (408) 942-3085** **E-Mail: compliance@ubnt.com**

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Alex Macon
Project Test Engineer

Test Report Revision History

Revision	Date	Revised By	Reason for Revision
1.0	June 26, 2015	Alex Macon	Original Document

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Non-accredited tests contained in this report:

N/A

The applicant has been cautioned as to the following

15.21 - Information to User

The user's manual or instruction manual for an intentional radiator shall caution the user that changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment.

15.27(a) - Special Accessories

Equipment marked to a consumer must be capable of complying with the necessary regulations in the configuration in which the equipment is marketed. Where special accessories, such as shielded cables and/or special connectors are required to enable an unintentional or intentional radiator to comply with the emission limits in this part, the equipment must be marketed with, i.e. shipped and sold with, those special accessories. However, in lieu of shipping or packaging the special accessories with the unintentional or intentional radiator, the responsible party may employ other methods of ensuring that the special accessories are provided to the consumer without an additional charge.

Information detailing any alternative method used to supply the special accessories for a grant of equipment authorization or retained in the verification records, as appropriate. The party responsible for the equipment, as detailed in § 2.909 of this chapter, shall ensure that these special accessories are provided with the equipment. The instruction manual for such devices shall include appropriate instructions on the first page of text concerned with the installation of the device that these special accessories must be used with the device. It is the responsibility of the user to use the needed special accessories supplied with the equipment.

Standard Test Conditions Engineering Practices

Except as noted herein, the following conditions and procedures were observed during the testing:

In accordance with ANSI C63.10-2013 and unless otherwise indicated in the specific measurement results, the ambient temperature of the actual EUT was maintained within the range of 10° to 40°C (50° to 104°F) unless the particular equipment requirements specified testing over a different temperature range. Also, unless otherwise indicated, the humidity levels were in the range of 10% to 90% relative humidity.

Measurement results, unless otherwise noted, are worst-case measurements.

Environmental Conditions		
Temperature (ºC)	**Humidity (%)**	**Pressure (mbar)**
24.4 – 25.1	30.1 – 34.7	964.5 – 966.1

EUT Operation during Tests

The EUT was configured to run in a continuous data stream using ART software through a POE adaptor and Ethernet connection.

EUT Description
Model: NBE-M5-16
Description: NanoBeam M5 16
Firmware: N/A
Software: N/A
Serial Number: N/A
Additional Information: The EUT is a 2x2 MIMO 802.11n radio

EUT Specifications

Equipment Code	NII
Model(s)Tested	NBE-M5-16
Model(s) covered	NBE-M5-16
Maximum Conducted Output Power	25.5 dBm
Frequency Range	5150-5250 MHz
Bandwidths	-40°C to 75°C
Data Rates	10/20/30/40 MHz
Modulations	6, 9, 12, 18, 24, 36, 48, 54, MCS0, MCS1, MCS2, MCS3, MCS4, MCS5, MCS6, MCS7, MCS8, MCS9

Antenna List

No.	Manufacturer	Part #	Antenna Type	Peak Gain
1	Ubiquiti	NBE-M5-16	Dish	16 dBi

15.203: Antenna Requirement:

	The antenna is permanently attached to the EUT
	The antenna uses a unique coupling
X	The EUT must be professionally installed
	The antenna requirement does not apply

Accessories: None

Cables: None

Modifications: None

Test Results Summary

Specification	Test Name	Pass, Fail, N/A	Comments
§15.203	Antenna Requirements	Pass	
§15.207 §15.407(b)(6)	Line Conducted Emissions	Pass	
§15.407(a)(1)	Conducted Output Power	Pass	
§15.407(a)(1),(5)	Power Spectral Density	Pass	
§15.403(i) 15.407(a)(5)	26dB Occupied Bandwidth	Pass	
	99% Occupied Bandwidth		
§15.407(b)(1)	Undesirable Emissions	Pass	
§15.205 §15.407(b)(1),(5),(6)(7)	General Field Strength Limits (Restricted Bands and Radiated Emission limits)	Pass	
§15.407(g)	Frequency Stability	Pass	
§15.407(f)	RF Exposure	Pass	

References	Description
CFR47, Part 15, Subpart B	Unintentional Radiators
CFR47, Part 15, Subpart C	Intentional Radiators
CFR47, Part 15, Subpart E	Unlicensed Nation Information Infrastructure Devices (U-NII)
ANSI C63.10-2009	American National standard for testing Unlicensed Wireless Devices
ANSI C63.4-2009	Method and Measurements of Radio-Noise Emissions from low-Voltage Electrical and Electronic Equipment in the range 9kHz to 40GHz.
ISO/IEC 17025:2005	General requirements for the Competence of Testing and Calibrations Laboratories
KDB 644545 D03	Guidance for IEEE 802 11ac New Rules
KDB 789033 D02	General U-NII Test Procedures New Rules V01
KDB 926956 D01	U-NII Transition Plan

Peak Output Power
Engineer: Alex Macon
Test Date: 6/25/15

Test Requirements

(iii) For fixed point-to-point access points operating in the band 5.15-5.25 GHz, the maximum conducted output power over the frequency band of operation shall not exceed 1 W. Fixed point-to-point U-NII devices may employ antennas with directional gain up to 23 dBi without any corresponding reduction in the maximum conducted output power. For fixed point-to-point transmitters that employ a directional antenna gain greater than 23 dBi, a 1 dB reduction in maximum conducted output power is required for each 1 dB of antenna gain in excess of 23 dBi. Fixed, point-to-point operations exclude the use of point-to-multipoint systems, omnidirectional applications, and multiple collocated transmitters transmitting the same information. The operator of the U-NII device, or if the equipment is professionally installed, the installer, is responsible for ensuring that systems employing high gain directional antennas are used exclusively for fixed, point-to-point operations.

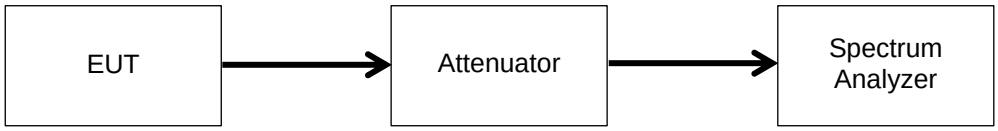
Test Procedure

The RF power was calculated using the spectrum analyzers' band power function per Method SA-1 from KDB 789033 D02 General U-NII Test Procedures New Rules v01. Measurements were made at the low, mid, and high channels of the band.

The Spectrum Analyzer was set to the following:

a. RBW = 1 MHz
b. VBW ≥ 3 MHz
c. Sweep time = auto
d. Detector = RMS
e. 100 traces in power averaging mode

Test Setup



Test Results

Band Width	Frequency	Data Rate	TP	J1 Level	J3 Level	J1 Level	J3 Level	Combined Output Power	Limit	Margin
MHz	MHz			dBm	dBm	mW	mW	dBm	dBm	dB
10	5160	6	20	19.1	21.8	81.3	151.4	23.7	30	-6.3
10	5200	6	20	22.2	22.8	166.0	190.5	25.5	30	-4.5
10	5245	6	20	19.6	21.4	91.2	138.0	23.6	30	-6.4
20	5165	6	20	19.3	20.9	85.1	123.0	23.2	30	-6.8
20	5200	6	20	21.9	21.0	154.9	125.9	24.5	30	-5.5
20	5240	6	20	19.3	21.9	85.1	154.9	23.8	30	-6.2
30	5170	6	15	16.0	18.3	39.8	67.6	20.3	30	-9.7
30	5200	6	20	21.1	21.1	128.8	128.8	24.1	30	-5.9
30	5235	6	20	19.2	21.9	83.2	154.9	23.8	30	-6.2
40	5175	f0	11	13.2	16.2	20.9	41.7	18.0	30	-12.0
40	5200	f0	20	21.3	21.0	134.9	125.9	24.2	30	-5.8
40	5230	f0	20	19.6	22.2	91.2	166.0	24.1	30	-5.9

Transmitter Power Spectral Density
Engineer: Alex Macon
Test Date: 6/25/15

Test Requirements

(iii) For fixed point-to-point access points operating in the band 5.15-5.25 GHz fixed point-to-point U-NII devices may employ antennas with directional gain up to 23 dBi without any corresponding reduction in the maximum power spectral density. For fixed point-to-point transmitters that employ a directional antenna gain greater than 23 dBi, a 1 dB reduction in the maximum conducted power spectral density is required for each 1 dB of antenna gain in excess of 23 dBi. Fixed, point-to-point operations exclude the use of point-to-multipoint systems, omnidirectional applications, and multiple collocated transmitters transmitting the same information. The operator of the U-NII device, or if the equipment is professionally installed, the installer, is responsible for ensuring that systems employing high gain directional antennas are used exclusively for fixed, point-to-point operations.

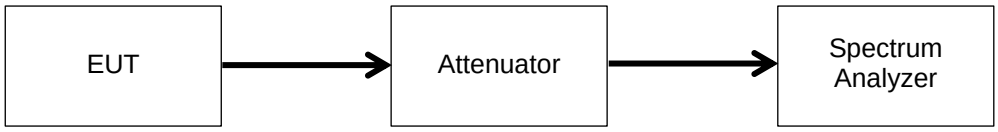
Test Procedure

The Power Spectral Density was measured using the method per SA-1 from KDB 789033 D02 General U-NII Test Procedures New Rules v01. Measurements were made at the low, mid, and high channels of the band. The maximum PSD was determine by finding the peak value across the carrier bandwidth.

The Spectrum Analyzer was set to the following:

a. RBW = 1 MHz
b. VBW ≥ 3 MHz
c. Span 1.5 * BW
d. Sweep time = auto
e. Detector = RMS
f. 100 traces in power averaging mode

Test Setup



Test Results

Band Width	Frequency	Data Rate	TP	J1 Level	J3 Level	J1 Level	J3 Level	Combined Spectral Density	Limit	Margin
MHz	MHz			dBm	dBm	mW	mW	dBm	dBm	dB
10	5160	6	20	10.8	13.4	12.0	21.9	15.3	17	-1.7
10	5200	6	20	13.8	13.2	24.0	20.9	16.5	17	-0.5
10	5245	6	20	11.4	13.2	13.8	20.9	15.4	17	-1.6
20	5165	6	20	8.1	9.7	6.5	9.3	12.0	17	-5.0
20	5200	6	20	10.8	9.7	12.0	9.3	13.3	17	-3.7
20	5240	6	20	8.3	10.6	6.8	11.5	12.6	17	-4.4
30	5170	6	15	2.8	5.1	1.9	3.2	7.1	17	-9.9
30	5200	6	20	8.0	7.9	6.3	6.2	11.0	17	-6.0
30	5235	6	20	6.1	8.6	4.1	7.2	10.5	17	-6.5
40	5175	f0	11	-1.4	1.6	0.7	1.4	3.4	17	-13.6
40	5200	f0	20	6.8	6.5	4.8	4.5	9.7	17	-7.3
40	5230	f0	20	5.1	7.6	3.2	5.8	9.5	17	-7.5

Undesirable Emissions Conducted
Engineer: Alex Macon
Test Date: 6/22/15

Test Requirements

Unwanted Emissions that fall Outside Restricted Bands

For transmitters operating in the 5.15-5.25 GHz band:

All emissions outside of the 5.15-5.35 GHz band shall not exceed an e.i.r.p. of −27 dBm/MHz. As specified in § 15.407(b), emissions above 1000 MHz that are outside of the restricted bands are subject to a maximum emission limit of -27 dBm/MHz. However, an out-of-band emission that complies with both the peak and average limits of § 15.209 is not required to satisfy the -27 dBm/MHz maximum emission limit.

The emission measurements shall be performed using a minimum resolution bandwidth of 1 MHz. A lower resolution bandwidth may be employed near the band edge, when necessary, provided the measured energy is integrated to show the total power over 1 MHz

The provisions of §15.205 apply to intentional radiators operating under this section

Unwanted emissions below 1 GHz must comply with the general field strength limits set forth in §15.209.

For Conducted Unwanted Emissions in the Restricted Bands

For conducted measurements above 1000 MHz, EIRP was determined and then the field strength computed by the following:
E[dBµV/m] = EIRP[dBm] - 20 log(d[meters]) + 104.77, where E = field strength and d = 3m
E[dBµV/m] = EIRP[dBm] + 95.2, for d = 3 meters.

Test Procedure

Per KDB 789033 D02 General U-NII Test Procedures New Rules v01 conducted RF port measurements were made in lieu of radiated. In addition, Cabinet Emissions measurements were performed in a semi-anechoic chamber with the antenna port terminated by a matching load. See additional section for Radiated Emissions.

The following criteria were addressed:

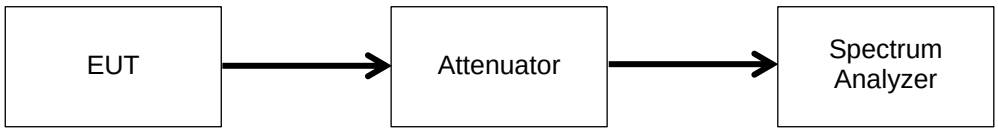
The Spectrum Analyzer was set to the following for emissions > 1000MHz:

a. RBW = 1 MHz
b. VBW ≥ 3 MHz
c. Detector = Peak.
d. Sweep time = auto
e. Trace mode = max hold
    1. Note: For emissions where the peak exceeded that of the average 15.209 emission limit the following was performed.
f. RBW = 1 MHz
g. VBW ≤ RBW/100 (i.e., 10 kHz) but not less than 10 Hz

For emissions below 1000MHz the Spectrum Analyzer settings were as follows:

a. RBW = 100 kHz
b. VBW ≥ 300 kHz
c. Detector = Peak
d. Sweep time = auto
e. Trace mode = max hold

Test Setup



Test Results: **See Annex A: Undesirable Emissions Conducted**

Undesirable Emissions Radiated
Engineer: Alex Macon
Test Date: 6/26/15

Test Requirements

The provision of §15.209 were applied. In addition the requirements of §15.205 were also applied.

FCC Part 15 Subpart C Paragraph 15.209(a) Limits

Frequency (MHz)	Frequency (microvolts/meter)	Frequency (meter)
0.009-0.490	2400/F(kHz)	300
0.490-1.705	24000/F(kHz)	30
1.705-30	30	30
30-88	100	3
88-216	150	3
216-960	200	3
Above 960	500	3

Remarks: E field strength (dBµV/m) = 20 log E field strength (uV/m)

Test Procedure

The EUT was setup in accordance with ANSI C63.10. 2013 and tested per KDB 789033. The antenna was replaced with non-radiating matched load. The EUT is placed on non-conductive platform at a height of 0.8 meters above the ground plane of the semi-anechoic chambers. The EUT was rotated 360 degrees and the receive antenna raised and lowered to find the maximum emissions from 30MHz to the 10th harmonic of the fundamental. The EUT was set to the maximum power level allowed and the low, mid, and high channels were investigated for emissions.

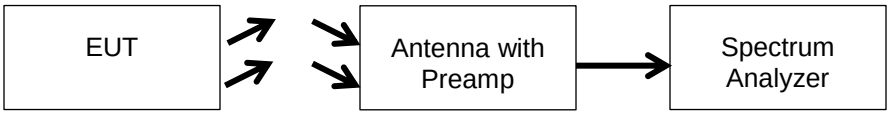
The Spectrum Analyzer was set to the following for emissions > 1000MHz:

a. (RBW = 1 MHz
b. VBW ≥ 3 MHz
c. Detector = Peak
d. Sweep time = auto
e. Trace mode = max hold
    1. Note: For emissions where the peak exceeded that of the average 15.209 emission limit the following was performed.
f. RBW = 1 MHz
g. VBW ≤ RBW/100 (i.e., 10 kHz) but not less than 10Hz

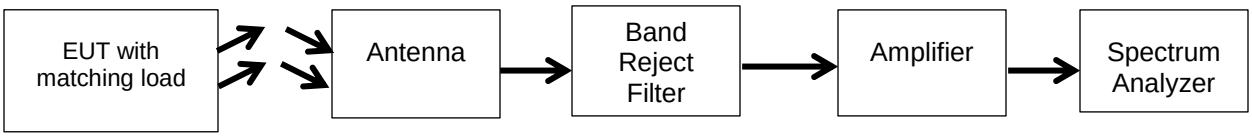
For emissions below 1000MHz the Spectrum Analyzer settings were as follows:

a. RBW = 100 kHz
b. VBW ≥ 300 kHz
c. Detector = Peak
d. Sweep time = auto
e. Trace mode = max hold
    1. Note: A quasi peak detector was used for emissions where the peak exceeded that of the average 15.209 emission limits

Test Setup below 1000MHz



Test Setup above 1000MHz



Test Results: **See Annex B: Undesirable Emission Radiated**

Occupied Bandwidth
Engineer: Mark Sechrist
Test Date: 6/19/15

Test Requirement

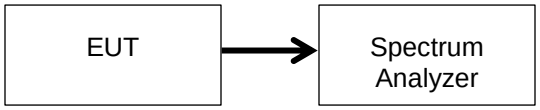
The emission bandwidth shall be determined by measuring the width of the signal between two points, one below the carrier center frequency and one above the carrier center frequency, that are 26 dB down relative to the maximum level of the modulated carrier. Determination of the emissions bandwidth is based on the use of measurement instrumentation employing a peak detector function with an instrument resolution bandwidth approximately equal to 1.0 percent of the emission bandwidth of the device under measurement

Test Procedure

The Spectrum Analyzer was set to the following parameters:

a. RBW = approximately 1% of the emission bandwidth.
b. VBW > RBW.
c. Detector = Peak.
d. Trace mode = max hold.

Test Setup



Test Results: **See Annex C: Occupied Bandwidth**

Frequency Stability
Engineer: Mark Sechrist
Test Date: 6/26/15

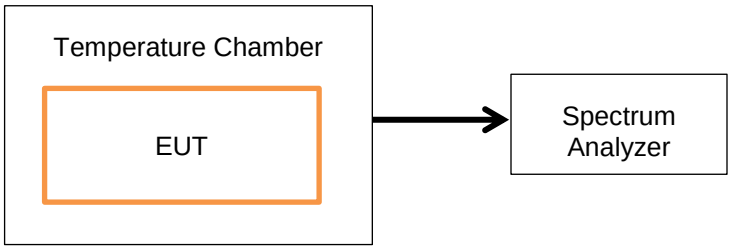
Test Requirement

Manufacturers of U-NII devices are responsible for ensuring frequency stability such that an emission is maintained within the band of operation under all conditions of normal operation as specified in the user's manual.

Test Procedure

a. The EUT was placed into a temperature chamber and the temperature ranges were set to the manufacturers' specifications.
b. The RF output of the EUT was connected to a spectrum analyzer
c. The lowest and highest channels of the band were set to transmit
d. The carrier plots were measured to insure that the 26dB band width remained within the band over the prescribed temperature extremes.

Test Setup



Test Results: **See Annex D: Frequency Stability**

RF Exposure
Engineer: Alex Macon
Test Date: 6/26/15

Requirements

U-NII devices are subject to the radio frequency radiation exposure requirements specified in §1.1307(b), §2.1091 and §2.1093 of this chapter, as appropriate. All equipment shall be considered to operate in a "general population/uncontrolled" environment. Applications for equipment authorization of devices operating under this section must contain a statement confirming compliance with these requirements for both fundamental emissions and unwanted emissions. In addition, systems operating under the provisions of this section shall be operated in a manner that insures that the public is not exposed to radio frequency energy levels in excess of the Commission's guidelines.

Exposure Limits

At operating frequencies less than or equal to 6 GHz, the limits for maximum permissible exposure (MPE) shall be used to evaluate the environmental impact of human exposure to radiofrequency (RF) radiation as specified in Section 1.1307(b), except for portable devices as defined in §2.1093 as these evaluations shall be performed according to the SAR provisions in §2.1093 of this chapter.

MPE Limit Calculations

Exposure Limit 1mW/cm^2

Source Based Time Averaged Power Calculation

Average Power Calculations

Average Power = Peak Power * duty-cycle%

Tuned Frequency (MHz)	Conducted Peak Output Power (mW)	Duty Cycle (%)	Average Power (mW)
5200	355	100	355

MPE Evaluation

This is a **fixed/mobile** device used in uncontrolled /general population exposure environment.

Limits Uncontrolled Exposure	0.3-1.234 MHz	Limit [mW/cm²] = 100
47 CFR 1.1310	1.34-30 MHz	Limit [mW/cm²] = (180/f²)
Table 1, (B)	30-300 MHz	Limit [mW/cm²] = 0.2
	300-1500 MHz	Limit [mW/cm²] = f/1500
	1500-100,000 MHz	Limit [mW/cm²] = 1.0

Test Data

Test Frequency, MHz	5200
Power, Conducted, mW (P)	355
Antenna Gain Isotropic	16
Antenna Gain Numeric (G)	39.81
Antenna Type	Point to point
Distance (R)	20

$$S = \frac{P * G}{4\pi r^2}$$

Power Density (S) mw/cm^2	Power mW (P)	Numeric Gain (G)	Distance (r^2) cm
2.8116644119	355	39.81	20

Power Density (S) =	2.81
Limit =(from above table) =	1.0

The Power Density of 2.81 mw/cm^2 is over the limit of 1.0 mw/cm^2 for the uncontrolled /general population exposure environment so Minimum Safe Distance was calculated.

R=√(PG/4πL)

Distance (R) cm	Power mW (P)	Numeric Gain (G)	Limit (L)
33.54404605	355	39.81	1

The minimum safe distance is 33.5 cm.

A/C Powerline Conducted Emission

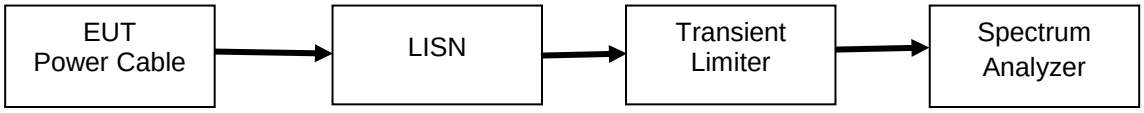
Engineer: Mark Sechrist

Test Date: 11/3/15

Test Procedure

The EUT power cable was connected to a LISN and the monitored output of the LISN was connected to a transient limiter, which then connected directly to a spectrum analyzer. The conducted emissions from 150 kHz to 30 MHz were measured and compared to the specification limits.

Test Setup



Test Results: **See Annex E: A/C Powerline Conducted Emission**

Test Equipment Utilized

Description	Manufacturer	Model #	CT Asset #	Last Cal Date	Cal Due Date
Temperature Chamber	Tenney	Tenney Jr	i00027	NCR	NCR
EMI Receiver	HP	8546A	i00033	2/26/15	2/26/16
Preamplifier	HP	8447D	i00055	NCR	NCR
Horn Antenna	EMCO	3116	i00085	NCR	NCR
Horn Antenna, Amplified	ARA	DRG-118/A	i00271	5/8/14	5/8/16
Horn Antenna, Amplified	ARA	MWH-1826/B	i00273	4/9/12	4/9/2015
Humidity / Temp Meter	Newport	IBTHX-W-5	i00282	4/1/15	4/1/16
Spectrum Analyzer	Agilent	E4407B	i00331	6/13/14	6/13/15
Data Logger	Fluke	Hydra Data Bucket	i00343	3/24/15	3/24/16
Bi-Log Antenna	Schaffner	CBL 6111D	i00349	10/8/13	10/8/15
EMI Analyzer	Agilent	E7405A	i00379	2/5/15	2/5/16
Standard Gain Horn Kit	Pacific Millimeter Products	Mixer Mdl: MD1A 60 – 90 GHz Horn Mdl: EM 90 – 140 GHz Horn Mdl: FM	i00394	NCR	NCR
3 Meter Semi-Anechoic Chamber	Panashield	3 Meter Semi-Anechoic Chamber	i00428	11/26/13	11/26/15
Spectrum Analyzer	Agilent	E4446A	S/N:MY46180386	10/26/14	10/26/16
Spectrum Analyzer	Agilent	E4448A	S/N:US42510268	10/23/13	10/23/15
Spectrum Analyzer	Agilent	E4407B	S/N:SG44210864	1/8/15	1/8/16
Spectrum Analyzer	Agilent	E4448A	S/N:MY46180566	3/20/15	12/1/16

In addition to the above listed equipment standard RF connectors and cables were utilized in the testing of the described equipment. Prior to testing these components were tested to verify proper operation.

END OF TEST REPORT